DOCUMENT RESUME

ED 064 081 SE 013 651

TITLE	Science: Scientific Mathematics, Dynamics, Kinematics. Authorized Course of Instruction for the Quinmester Program.
INSTITUTION	Dade County Public Schools, Miami, Fla.
PUB DATE	71
NOTE	49p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Instruction; Kinetics; Mathematical Applications; *Objectives; *Physics; Secondary School Science; *Teaching Guides; Units of Study (Subject Fields)
IDENTIFIERS	*Quinmester Program

ABSTRACT

Performance objectives are stated for each of the secondary school units included in this package of instructional guides prepared for the Dade County Florida Quinmester Program. All three units deal with mathematical applications or concepts in physics dealing with mathematical relationships: "Scientific Mathematics," "Dynamics," and "Kinematics." Lists of texts, films, filmstrips, and other instructional aids are included in each unit. A course outline summarizing the content of the units, numerous suggestions for experiments, activities, and projects are given. A master sheet showing the relationship of each suggested activity to the objectives of the package is appended to each booklet. (TS)

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

SCIENTIFIC MATHEMATICS

5344.01
3266.26

SCIENCE
(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION•1971

SCIENTIFIC MATHEMATICS
5344.01
3266.26
SCIENCE
(Experimental)

Written By Leonard Roesler and Sidney Hollander
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Fla.
1971

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Dade County Public Schools
Miami, Florida 33132

Published by the Dade County School Board

Copies of this publication may be obtained through

Textbook Services
2210 S. W. Third Street
Miami, Florida 33135

Price: $.75

TABLE OF CONTENTS

SCIENTIFIC MATHEMATICS

COURSE DESCRIPTION Scientific Mathematics introduces the student to the mathematical concepts necessary for success in all major scientific areas of study.

ENROLLMENT GUIDELINES This course is recommended for students in the 9th or 10th grades who intend to place strong emphasis in scientific course work.

STATE ADOPTED TEXTS

1. Abraham, Norman; Balch, Patrick; Chaney, Donald; and Rohrbaugh, Lawrence. Interaction Of Matter And Energy. Chicago: Rand McNally and Company, 1968.

2. Dolciani, Mary; Berman, Simon; and Wooton, William. Modern Algebra and Trigonometry. Boston: Houghton Mifflin Co., 1963.

3. Dolciani, Mary; et al. Modern School Mathematics: Algebra 2 and Trigonometry. Boston: Houghton Mifflin Co., 1968.

4. Skeen, Kenneth C. Using Modern Mathematics. Syracuse: L. W. Singer Co., - Random House Inc., 1966.

5. Skeen, Kenneth C. and Whitmore, Edward H. Modern Mathematics Book I. Syracuse: L. W. Singer Co., Random House Inc., 1966.

6. Skeen, Kenneth C. and Whitmore, Edward H. Modern Mathematics Book II. Syracuse: L. W. Singer Co. - Random House Inc., 1966.

7. Woodruff, Bobby J. Terms, Tables and Skills For The Physical Sciences. Morristown, N.J.: Silver Burdett Company, 1966.*

*Strongly suggested for text.

PERFORMANCE OBJECTIVES

1. The student will use scientific notation to solve problems.

2. a. Given measurements and the uncertainty of the instrument used, the student will compute and state the uncertainty of the sum, difference, quotient and product of the measurements using:
   (1) Significant figures
   (2) Maximum and minimum quantity or percent deviation
   b. Given any measurement and its accepted value, the student will compute the percent of error.

3. Given the three systems of measurement (mks, cgs, Eng.), the student will differentiate among the three systems.

4. Given instruction in basic slide rule operation, the student will compute multiplication, division, combination and root extraction problems.

5. Using ratio, direct proportion, indirect proportion and constant of proportionality the student will solve problems.

6. Given a formula and the values for all but one variable and the values of necessary constants the student will compute the numerical value of the unknown variable.

7. Given suitable sets of data the student will:
   a. Construct broken line graphs
   b. Construct smooth line graphs
   c. Predict trends
   d. Interpret the meaning of areas under the curves

8. Given appropriate problems the student will compute the probability (chance) of occurence of one event, sets of events, ordered set of events, and combination of occured and non-occured events.

9. Given a set of data the student will compute the following:
   a. Range
   b. Median
   c. Mode
   d. Mean
   e. Frequency distribution and graph
   f. Coefficient of correlation (optional)

10. Mole Concept: Given the chemical formula and a periodic chart, the student will compute molar mass of any pure substance. (optional)

COURSE OUTLINE

I. Scientific Notation
   A. Introduction
      1. Definition of scientific notation
      2. Ease in writing large and small numbers
   B. Conversion
      1. Change from decimal notation to scientific notation
      2. Change from scientific notation into decimal notation
   C. Exponents
      1. $10^x \, 10^y = 10^{x+y}$
      2. $\frac{10^x}{10^y} = 10^{x-y}$
   D. Operations (with special emphasis on units)
      1. Multiplication of numbers in scientifiic notation
      2. Division of numbers in scientific notation
      3. Combination of above
      4. Addition and subtraction of numbers in scientific notation

II. Uncertainty of Measurement
   A. Accuracy
      1. Maximum error
      2. Expressed as $\pm$ quantity or percentage
   B. Order of magnitude
   C. Practical uses in science

III. Systems of Measurement
   A. Introduction
      1. Need to measure
      2. Definition of
         (a) Space
         (b) Matter and weight
         (c) Time
         (d) Temperature
   B. Three Systems of Measurement
      1. mks
      2. cgs
      3. English

IV. Introduction to the Slide Rule
   A. Multiplication and division
   B. Root extractions

V. Ration and Proportion
   A. Ratio
      1. Direct
      2. Indirect (inverse) proportion
   B. Constant of proportionality
   C. Application of slide rule to ratio and proportion

VI. Formulas and their use in solving problems
   A. Four-step procedure
      1. Copy formula
      2. Substitution
      3. Simplification
      4. Computation
   B. Factor-Label method

VII. Graphing
   A. Reading graphs
   B. Construction of line graphs
      1. Smooth line
      2. Broken line
   C. Trend analysis
   D. Area under the curve
      1. $d=vt$
      2. $v=1/2\ gt^2$

VIII. Probability
   A. Definition of probability
   B. One event
   C. Set of events
   D. Ordered set of events
   E. Combination of occured and non-occured events
   F. Permutation and combinations (optional)

IX. Statistics
   A. Need of statistics in science
   B. Data
      1. Bias
      2. Need of large sample
   C. Statistical Methods
      1. Range
      2. Median
      3. Mode
      4. Mean
      5. Frequency distribution and graph (optional)
      6. Coefficient of correlation (optional)
   D. Normal bell (distribution) curve
      1. Standard deviation
      2. Uses

X. Mole Concept (optional)
   A. Definition of mole
   B. Need of mole as a measure
   C. Definition of atomic mass units
   D. Chemical formulas

EXPERIMENTS

Abraham, Balch, Chaney, and Rohrbaug. Interaction Of Matter and Energy. Chicago: Rand McNally & Co., 1968.

1. Measurement of Length and Area (Investigation 16, p. 117)
2. Determining the Volume of Solids (Investigation 17, p. 118)
3. Mass and Volume of Water (Investigation 18, p. 123)
4. Calibrating a Thermometer (Investigation 34, p. 191)
5. Mass and Volume of Liquids Other Than Water (Investigation 19, p. 125)
6. Determining the Density of Various Objects (investigation 20, p. 127)

Biological Science Curriculum Study. Biological Science: Molecules to Man. Boston: Houghton Mifflin Co., 1969.

7. Measurement of Biological Materials (Lab 1)
8. Qualitative Observation of Living Things (Lab 2)
9. Growth Curves (Lab 32)
10. A Study In Human Population Genetics (Lab 37)

IPS Group Educational Services Incorporated. Introductory Physical Science. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967.

11. Measuring Volume by Displacement of Water (p. 9)
12. Thermal Expansion of Liquids (p. 34)
13. Effect of Temperature on Solubility (p. 58)
14. Quantity of Heat: The Calorie (p. 205)
15. Specific Heat of a Solid (p. 212)
16. Heat of Solution (p. 214)
17. Heat of Fusion (p. 214)

Geffner and Lauren. Experimental Chemistry. New York: Amsco School Publications, 1968.

18. Measuring Matter (Exp. 2, pp. 9-13)

Bulletin 8F Tenative. Supplementary Activities. Miami: Dade County Board of Public Instruction, 1969.

19. Goldfish Observation (p. 1)
20. Girls, Boys, Grasshoppers (p. 3)
21. Organizing Knowledge (p. 7)
22. Potato Measurement (p. 10)
23. Learning To Use the Balance (p. 12)
24. Telling Time by Measuring the Speed of Ants (p. 14)
25. Cricket Thermometers (p. 16)
26. Graphing Problems (p. 17)

Davis, Joseph E., et al. Chemistry: Experiments and Principles Laboratory Manual. Atlanta: Raytheon, 1968.

First five investigations lend themselves to measurement, graphing, and uncertainties.

TRANSPARENCIES

1. Scientific Measurement (verniers - caliper - micrometers)
   B4 Av #2-00158
2. Accurate Measurement of Weight
   AV #2-0027 1 static, 2 diagram

DADE COUNTY 16 mm FILMS

1. Measurement in Physical Science
   AV #1-10452 14 min. BW
2. Measurement
   AV #1-10676 2 min. BW
3. Measuring Large Distances
   AV #1-30252 29 min. BW
4. Measuring Short Distances
   AV #1-10679 20 min. BW
5. Bar Graphs and Pictograms
   AV #1-30029 28 min. BW
6. Equations with Unknown Exponents
   AV #1-30183 30 min. BW
7. Formulas in Mathematics
   AV #1-01349 10 min. C
8. Language of Graphs
   AV #1-10128 14 min. C
9. Line Graphs and Statistical Averages
   AV #1-30030 29 min. BW
10. Metric System, the
    AV #1-0084 11 min. BW
11. Slide Rule, the: "C and D" Scales
    AV #1-10603 23 min. BW
12. Slide Rule: Percentages, Proportions, Square & Square Roots
    AV #1-10604 23 min. BW

PROJECTS AND/OR REPORTS

1. Student should find his weight and give % of error based on a scale calibrated in pounds. Similiar exercises could be done with age in years, months, etc., length of room in English and/or metric units.

2. What are logarithms? Explain how and why the C and D scales on the slide rule work.

3. Explain how the Egyptians were able to find the height of a tree by knowing the length of a stick's shadow.

4. Find the height of some object about school (flag pole, tree, etc.,) using a shadow.

5. What part does probability play in drawing a conclusion in an experiment. When a scientist states a "law" about something occurring does that mean that the probability of that event occurring is one? Answer this question in reference to The Law of Gravity, The Law of Conservation of Matter (of 25 years ago) and the present day Law of Conservation of Matter.

6. Toss 10 coins 100 times and record the number of heads thrown on each toss. Graph the data collected; labeling horizontal axis the "number of heads" (1-10) and the vertical axis the "frequency of occurrence" of the number of heads. Interpret the graph. Contrast a priori and posteriori data.

REFERENCES

1. Geerts, W. Working With a Slide Rule (a programmed learning text). Princeton, New Jersey: Averbach Publishers Inc., 1971.

2. Himes, Gary K. Solving Problems in Chemistry, Columbus Ohio: Merrill, 1966.

3. Linn, Charles. Probability and Statistics: An Introduction With Applications In the Sciences. Columbus, Ohio: Am. Ed. Publications, 1963.

4. Mann, William. Probability and Statistics. Columbus Ohio: Independent Learning Series, 1968.

5. Youden, W. J. Experimentation and Measurement. Washington, D.C.: National Science Teachers Association, 1966.

MASTER SHEET - SCIENTIFIC MATHEMATICS

Objectives	Laboratory Experiments	State Adopted	Supplementary References	Films	Transparencies
1	14, 15	7 pp. 13-16 4 pp. 282-285	2 pp. 9-15	6	
2	8, 11	7 pp. 17-21, 52-56 4 pp. 267-278	2 pp. 15-20 5	3, 4	2
3	1-4, 7, 17	7 pp. 1-12 1 pp. 109-134	2 pp. 1-9	1, 2, 3, 4, 10	1, 2
4		7 pp. 32-40 4 pp. 509-572	2 pp. 21-38 1	11, 12	
5	5, 6, 16	7 pp. 67-76 6 pp. 342-352 4 pp. 190-191			
6		7 pp. 22-24, 142		7	
7	9, 13, 26	7 pp. 64-78 4 pp. 233-238	5	5, 8, 9	
8	10	2 pp. 573-601 4 pp. 239-240 3 pp. 599-627	4 pp. 4-41 3 pp. 3-49 5		
9		7 pp. 50-59 4 pp. 238-248	4 pp. 42-69 5	9	
10		1 pp. 78-80	2 pp. 56-65		

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

Science: DYNAMICS I 5318.02

DADE COUNTY PUBLIC SCHOOLS
DIVISION OF INSTRUCTION•1971

DYNAMICS I
5318.02
SCIENCE
(Experimental)

Written by Ralph E. Petit and Robert C. Sanderson
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Fla.
1971

Dr. E. L. Whigham, Superintendent of Schools
Dade County Public Schools
Miami, Florida 33132

Published by the Dade County School Board

Copies of this publication may be obtained through

Textbook Services
2210 S.W. Third Street
Miami, Florida 33135

Price: $.75

TABLE OF CONTENTS

DYNAMICS I

COURSE DESCRIPTION:

A laboratory-oriented course which relates the causes of straight line motion and its changes to applied forces and the key concepts of kinematics.

ENROLLMENT GUIDELINES:

1. Strongly recommended if the student plans further studies in science, technology, or medicine.

2. Elective.

3. Successful completion of Kinematics is strongly recommended as an indicator of success in Dynamics I.

4. Dynamics I is prerequisite to Dynamics II.

STATE ADOPTED TEXTS

1. Genzer, Irwin and Youngner, Philip. Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

2. Miller, Franklin, Jr., et al. Concepts in Physics. Atlanta: Harcourt, Brace and World, Inc., 1969.

3. Rutherford, F. James, et al. The Project Physics Course Text. New York: Holt, Rinehart and Winston, Inc., 1970.

4. Williams, John E., et al. Modern Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

PERFORMANCE OBJECTIVES

1. Given certain demonstrations, the student will relate the concepts of force to the three key concepts of Physics.

2. Given laboratory opportunity, the student will discover the variable acceleration of weights when acted upon by constant forces.

3. Given laboratory opportunity, the student will discover the varying acceleration of weight when acted upon by different forces.

4. Given laboratory opportunity, the student will discover the constant acceleration of varying weights under free fall conditions.

5. Using data from his experiments, the student will identify the variable between horizontal and vertical motion.

6. Using data from previous experiments, the student will distinguish between mass and weight.

7. Given the opportunity to analyze experimental data, the student will synthesize Newton's Second Law of Motion ($F = ma$) and the vector nature of force.

8. Given various conditions of Newton's Second Law, student will be proficient in problem solving.

9. As a result of teacher demonstrations and class room demonstrations, the student will discover Newton's First and Third Laws of Motion (inertia, action and reaction).

10. After review and experimentation, the student will identify friction as a force that opposes motion.

11. Given laboratory opportunity, the student will devise a method of finding the magnitude of the frictional force.

12. Using experimental data, the student will generalize the concept of impulse leading to momentum change.

13. Using his experimental data, the student will identify momentum as the practical application of inertia, (Newton's First Law).

14. Using data from all experiments, the student will be proficient in problem-solving involving Newton's Laws of Motion.

15. Given a series of appropriate problems, the student will formulate the law of conservation of momentum.

16. Given experimental data, the student will discriminate among the concepts of work, kinetic energy, and potential energy.

17. Using data from all experiments, the student will be proficient in problem solving of work and energy, thereby developing the law of conservation of energy.

18. After demonstration and class discussion, the student will apply the concept of conservation of energy by solving problems involving all types of collisions.

COURSE OUTLINE

I. Laboratory investigation of relationship of force, weight, acceleration.

- A. Horizontal motion
  1. Constant force - variable weights
  2. Constant weight - variable force
- B. Downward vertical motion from rest with different weights.

II. Analysis of experiments

- A. Distinguish between mass and weight
- B. Newton's Second Law (F = ma)
- C. Newton's First and Third Law
- D. Vector nature of force

III. Friction

- A. Horizontal surface
- B. Inclined plane

IV. Impulse and momentum

- A. Change in momentum
- B. Conservation of momentum
- C. Vector nature of impulse and momentum

V. Work and Energy

- A. Work
- B. Kinetic energy
- C. Potential energy
- D. Conservation of energy
  1. Perfect elastic collisions
  2. Inelastic collisions

EXPERIMENTS

Dillon, Thomas J., and Smith, Malcolm K. Concepts in Physics Laboratory Manual. Atlanta: Harcourt, Brace and World, Inc., 1969.

1. Force and acceleration (Ex. 8, p. 15)
2. Mass and acceleration (Ex. 9, p. 16)
3. Inertial mass and gravitational mass (Ex. 10, p. 17)
4. Momentum changes (Ex. 13, p. 22)
5. Another look at momentum changes (Ex. 14, p. 23)
6. Conservation laws in collisions - data taking (Ex. 15, p. 24)
7. Conservation laws in collisions - analysis taking (Ex. 16, p. 25)
8. The mass of the earth (Ex. 19, p. 28)

Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

9. Newton's Second Law (Ex. 8, p. 42)
10. Mass and Weight (Ex. 9, p. 45)
11. Collisions in one dimension (Ex. 22, p. 140)
12. Collisions in two dimensions (Ex. 23, p. 142)
13. Conservation of energy (Ex. 24, p. 166)

Physical Science Study Committee. Physics Laboratory Guide. Atlanta: D. C. Heath and Co., 1965.

14. Changes in velocity with a constant force (Ex. III-1, p. 35)
15. The dependence of acceleration on force and mass (Ex. III-2, p. 37)
16. Inertia and gravitational mass (Ex. III-3, p. 38)
17. Forces on a ball in flight (Ex. III-4, p. 41)
18. Momentum changes in an explosion (Ex. III-6, p. 48)
19. The cart and the brick (Ex. III-8, p. 50)
20. A collision in two dimensions (Ex. III-9, p. 51)
21. Changes in potential energy (Ex. III-11, p. 55)
22. A head-on collision (Ex. III-13, p. 59)

Williams, John E. et al. Exercises and Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

23. Composition of forces (Ex. 6, p. 115)
24. Resolution of forces (Ex. 7, p. 117)
25. Coefficient of friction (Ex. 10, p. 123)
26. Momentum (Ex. 11, p. 125)
27. Conservation of energy (Ex. 16, p. 139)

DEMONSTRATIONS

See Additional Innovative Activities (p 11)

PROJECTS

1. Design and construct apparatus that could be used to prove that a feather and a piece of lead will fall the same distance in the same length of time.

2. Design and construct apparatus that will prove that a projectile falls from its projected path the same distance a vertically-falling body drops when both start at the same time.

3. Design and construct a Rube Goldberg device to show energy transformation.

4. Design and construct apparatus that could prove that the kinetic energy gained by a large metal ball in falling a given distance is equal to the work done in raising it and finally into heat energy when the ball has stopped.

5. Design and construct a simple roll-out and come-back toy.

6. Design and construct apparatus for measuring the muzzle velocity of a pellet gun.

7. Design and construct a small scale pile driver.

8. Design and construct a device which will measure friction force on the hull of a model boat.

9. Build a mockup of the force system in a 10-speed bike.

10. Design and build a "frictionless" surface.

11. Design and construct apparatus to measure static, kinetic, and rolling friction.

REPORTS

1. The study of Dynamics by scientists.
   A. (1600 A.D. - 1800 A.D.)
   B. (1800 A.D. - 1900 A.D.)
   C. (1900 A.D. - 1940 A.D.)
   D. (1940 A.D. - 1948 A.D.)
   E. (1948 A.D. - 1971 A.D.)
   F. (1971 A.D. - 2000 A.D.)
2. Rockets and acceleration.
3. What's good about friction?
4. What's bad about friction?
5. Purposes of streamlining cars and planes.
6. Conservation of energy in a hydro-electric plant.
7. Conservation of energy in a nuclear power plant.
8. Tires vs. pavement conditions vs. death.
9. Surfing on the runway (highway).
10. Surfing in the ocean.
11. Car safety, momentum, and kinetic energy.
12. Conservation of energy in a block colliding with spring situation.

FIELD TRIPS

1. Bowling alley
2. Billiard parlor
3. University of Miami auto safety track
4. Construction site
5. Drag races
6. Automobile brake-testing station
7. Electric generating plant
8. Biscayne Bay boat test
9. Target range
10. Bumperoos (Rt. 441, South Broward County Line)

RELATED SOLVED PROBLEMS

1. Castka, Joseph F. and Lefler, Ralph W. Physics Problems. New York: Holt, Rinehart and Winston, Inc. 1961. (pp. 166-188, 200-233).

2. Miller, Franklin, et al. Concepts in Physics, Teachers' Manual and Answer Key. Atlanta: Harcourt, Brace, Jovanovich, 1970. (pp. 36-103).

3. Physical Science Study Committee. P.S.S.C. Physics Teachers' Resource Book and Guide. Boston: D. C. Heath and Co., 1965. (Part 3).

4. Schaum, Daniel. Theory and Problems of College Physics, 6th Edition. New York: Schaum Publishing Co., 1961, Reprint 1966. (pp. 28-32 and 35-66).

5. Williams, John E., et al. Modern Physics Teachers' Edition. New York: Holt, Rinehart and Winston, Inc., 1968. (pp. T9-T46).

DADE COUNTY 16mm FILMS

1. Conservation of Energy (0313)
   AV# 1-30234 (MLA) 27 min. BW
2. Energy and Work (0311)
   AV# 1-30237 (MLA) 29 min. BW
3. Forces: Composition and Resolution (Coronet)
   AV# 1-10782 11 min. BW
4. Forces (0301)
   AV# 1-10694 (MLA) 23 min. BW
5. Free Fall and Projectile Motion (0304)
   AV# 1-30275 (MLA) 30 min. BW
6. Inertia (0302)
   AV# 1-30268 (MLA) 27 min. BW
7. Inertial Mass (0303)
   AV# 1-10691 (MLA) 20 min. BW
8. Mechanical and Thermal Energy (0312)
   AV# 1-10669, 22 min. BW

FILM LOOPS

The Project Physics Course Materials. New York: Holt, Rinehart and Winston, Inc., 1970. Super 8

Unit 1: Concepts of Motion

PP 1. Acceleration Due to Gravity: Method 1
PP 2. Acceleration Due to Gravity: Method 2
PP 5. Galilean Relativity: Part 1 - Ball Dropped From Mast of Ship
PP 7. Galilean Relativity: Part 3 - Projectile fired Vertically
PP 8. Analysis of a Hurdle Race: Part 1
PP 9. Analysis of a Hurdle Race: Part 2

Unit 3: The Triumph of Mechanics

PP 10. One Dimensional Collisons: Part 1
PP 11. One Dimensional Collisions: Part 2
PP 12. Inelastic One-Dimensional Collisions
PP 13. Two-Dimensional Collisions: Part 1
PP 14. Two-Dimensional Collisions: Part 2
PP 15. Inelastic Two-Dimensional Collisions
PP 16. Scattering of a Cluster of Objects
PP 17. Explosion of a Cluster of Objects
PP 18. Finding the Speed of a Rifle Bullet: Method 1
PP 19. Finding the Speed of a Rifle Bullet: Method 2
PP 20. Recoil
PP 21. Colliding Freight Cars
PP 22. Dynamics of a Billiard Ball
PP 23. A Method of Measuring Energy: Nails Driven into Wood
PP 24. Gravitational Potential Energy
PP 25. Kinetic Energy
PP 26. Conservation of Energy: Pole Vault
PP 27. Conservation of Energy: Aircraft Takeoff

NOTE: (All Loops $24.95 each.)

TRANSPARENCIES

The Project Physics Course Materials. New York: Holt, Rinehart and Winston, Inc., 1970.

Unit 1:

1. The Tractor-Log Problem
2. One Dimensional Collisions
3. Equal Mass Two-Dimensional Collisions
4. Unequal Mass Two-Dimensional Collisions
5. Inelastic Two-Dimensional Collisions
6. Slow Collisions

R. C. A. "Educator-Aides". Camden, 8, New Jersey: R.C.A. Educational Services, R.C.A. Service Company, 1962.

7. Relationship of Mass and Force Units
8. Component Force Vectors
9. Resolution of Force by Parallelogram Method
10. Resolution of Force on an Acute Angle
11. Inclined Plane
12. Parallel Forces
13. Equilibrium
14. Friction
15. Newton's First Law of Motion
16. Newton's Second Law
17. Newton's Second Law Gives Acceleration
18. Impulse and Momentum
19. Newton's Third Law
20. Effects of Friction
21. Variation of Gravity With Distance

SUGGESTED DISCUSSION QUESTIONS

1. What does your "weight" represent?
2. Can you prove that your weight is a constant?
3. Would you weigh the same on the moon? --- Why?
4. Can you think of anything that is moving that will never stop?
5. Is anything stopped? i.e., completely at rest?
6. If you want to travel at 30 miles per hour on a horizontal surface, why must you "accelerate"?
7. What friction must you overcome in question 6?
8. By the way, what is friction?
9. How about it -- can anyone design a perpetual motion machine?
10. Why is it easier to move in air than in water?
11. What's so cool about streamlining?
12. Leap from a canoe to a dock -- what happens?
13. What would a truck driver experience, relative to motion, if he lost all of his load without knowing it?
14. Which is more important in driving golf balls, a heavy club or speed?
15. How about bowling and billiards?
16. In terms of impulse, what's the difference between slowing a car for a red light and/or hitting an oak tree?
17. Give as many examples of the law of inertia as possible.
18. Explain the sensations you feel in an elevator accelerating upward and then accelerating downward.
19. How do seat belts help prevent injuries in auto acidents?
20. Why does a baseball pitcher "wind up" before throwing the ball?
21. What are the dimensions of work, energy and force in L, M, and T?
22. What happens to the momentum of a car that collides with a stone wall and comes to rest?
23. No work is done in carrying a bag of potatoes horizontally at a constant speed. Why?
24. Explain why a free falling body,starting from rest, falls only 16 feet the first second and acquires a velocity of 32 feet/second.
25. Why is it dangerous to conduct low-altitude bombing?
26. Give examples to show that horizontal and vertical components of velocity are independent of each other.
27. How is the weight of a body related to the mass of the body?
28. What is meant by weightlessness? By pulling so many "g's" of force?
29. Explain the motion of a body falling through a hole cut through the earth from the north to the south pole.
30. How could you use an inclined plane to measure the coefficient of rolling and sliding friction?
31. Why is it necessary for us to choose a point of zero potential energy?
32. Is momentum conserved in a sky-rocket? How?
33. Can we really conserve kinetic energy?
34. What is efficiency (mechanical)?
35. What is mechanical advantage?
36. Does anyone know what we mean by power?
37. What is centrifugal force?
38. Why does a centrifuge work?
39. How can a wall exert twice the impulse of a ball that hits?

INNOVATIVE ACTIVITIES

1. Have students find the coefficient of sliding friction of a penny sliding down an inclined plane.

2. Have students bring in toys of different types to show energy changes that take place in many of them.

3. Time a bagel as it goes down planes of various degrees.

4. Determine horse power used by a student running up stairs.

5. Weigh students and compute their masses in various systems.

6. Make elastic vector table. Use mass and resultants to predict motion.

7. Design and construct a force resolution board.

8. Demonstrate loss of kinetic energy due to friction by frictionless surface.

9. Demonstrate terminal velocity by ping-pong balls vs bearings.

10. Use a water container on wheels under pull of gravity to show acceleration as a function of mass.

11. Energy transfer toy (Pendulation)

12. Study straight line motion of Yo-Yo.

13. Electric train cars with magnets.

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1. Baker, D. Lee, et al. Elements of Physics. Atlanta: Allyn and Bacon, Inc., 1956.

2. Bennett, Clarence E. Physics Without Mathematics. New York: Barnes and Noble, 1949.

3. Carman, Robert A. A Programmed Introduction to Vectors. New York: Jolen Wylie and Sons, 1963.

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21. Williams, John E., et al. Modern Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

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22. Dillon, Smith. Concepts in Physics Laboratory Manual. Atlanta: Harcourt, Brace and World, Inc., 1969.

23. Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

24. P. S. S. C. Physics Laboratory Guide. Atlanta: D. C. Heath and Company, 1965.

25. Williams, John E., et al. Exercises and Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

MASTER SHEET - DYNAMICS I

Objectives	Texts	Experiments	Project	Report	Field Trips	Transparencies	Film	Film Loops	Discussion Questions	Related Problems	Innovative Activity	References
1		1, 2, 14, 15	1	1		7	4, 6, 7	PP 1 PP 2	6, 7, 1, 2, 3			
2 and 3	1 Ch. 4 2 Ch. 4 3 Ch. 3 4 Ch. 4	1, 2, 3, 14, 15, 16		1		7, 15, 16, 17	6, 7		7	1-5	3	All
4	1 Ch. 4 2 Ch. 3 3 Ch. 3 4 Ch. 4	17	12		9		5	PP 1 PP 2 PP 5 PP 7	24, 25, 28, 29	1-5		All
5	1 Ch. 4 2 Ch. 3 3 Ch. 2 4 Ch. 4					8, 9, 10	3		30	1-5		All
6	1 Ch. 5 2 Ch. 4 3 Ch. 3 4 Ch. 4	3, 10, 16				7	6, 7		1, 2, 3, 18	1-5	5	All
7	1 Ch. 4 2 Ch. 4 3 Ch. 3, 4, 9 4 Ch. 4	9	6, 8, 9, 10	1 A 2, 10	5, 6, 8, 10	16, 17		PP 18 PP 19	6, 10, 11, 13	1-5	10	All
8	1 Ch. 4 2 Ch. 4 3 Ch. 3, 4, 9 4 Ch. 4									1-5		All
9	1 Ch. 4, 6 2 Ch. 4 3 Ch. 3, 9, 10 4 Ch. 4					15, 19			12, 17	1-5		All
10 and 11	1 Ch. 8 2 Ch. 4 3 Ch. 3, 10 4 Ch. 4	17, 25	8, 11	3, 4 8, 9	3, 6	14, 20			6, 7, 8 9, 10 30	1-5	1, 9	All
12 and 13	1 Ch. 11 2 Ch. 6 3 Ch. 9 4 Ch. 4	4, 5, 6, 7 18, 19, 20		11	11 1, 2, 10	18		PP 16 PP 17 PP 20 PP 22	4, 5, 12 14, 15, 16, 19 20, 22 32, 39	1-5	12	All
14	1 Ch. 11 2 Ch. 6 3 Ch. 9 4 Ch. 4									1-5		All
15	1 Ch. 11 2 Ch. 6 3 Ch. 9 4 Ch. 4									1-5		All
16	1 Ch. 12 2 Ch. 5 3 Ch. 10 4 Ch. 6	21	3, 4, 5, 7		1, 2, 4, 5	11	2, 8	PP 23 PP 24 PP 25	14, 15, 23, 21, 31, 33, 34; 35, 36	1-5	4, 8, 11, 12	All
17	1 Ch. 12 2 Ch. 5 3 Ch. 10 4 Ch. 6									1-5		
18	1 Ch. 12 2 Ch. 5 3 Ch. 10 4 Ch. 6	6, 7, 11, 12, 13, 20, 22, 27	3, 4, 5, 6, 7	6, 7, 11, 12	2, 4, 5, 7, 10	2, 3, 4, 5, 6	1, 2, 8	PP 10 PP 11 PP 12 PP 13 PP 14 PP 15 PP 21 PP 26 PP 27	33	1-5	2, 11, 12, 13	All

AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

Science: KINEMATICS 5318.01

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION•1971

KINEMATICS

5318.01

SCIENCE

Written by Robert C. Sanderson and Ralph E. Petit
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Fla.
1971

Dr. E. L. Whigham, Superintendent of Schools
Dade County Public Schools
Miami, Florida 33132

Published by the Dade County School Board

Copies of this publication may be obtained through

Textbook Services
2210 S.W. Third Street
Miami, Florida 33135

Price: $.75

TABLE OF CONTENTS

KINEMATICS

COURSE DESCRIPTION:

A laboratory-oriented course developing systematic observations and measurements of motion in a straight line and the relationships among time, space, matter.

ENROLLMENT GUIDELINES:

1. Strongly recommended if student plans more studies in science, technology, or medicine.
2. Elective
3. Algebra I should be taken prior to Kinematics.
4. Kinematics is recommended as a prerequisite to Dynamics I.

STATE ADOPTED TEXTS

1. Genzer and Youngner. Physics. Morristown, New Jersey: Silver Burdett, 1969.
2. Miller, Dillon, Smith. Concepts in Physics. New York: Harcourt, Brace and World, 1969.
3. Rutherford, et al. The Project Physics Course, Units 1-6. New York: Holt, Rinehart, and Winston Inc., 1970.
4. Williams, Metcalf, Trinklein, Lefler. Modern Physics. New York: Holt, Rinehart, and Winston, Inc., 1968.

PERFORMANCE OBJECTIVES

The student will:

1. Discover key concepts (Time, Space, Matter) involved in straight line kinematics.

2. Using the three systems of measurement in selection of laboratory experiences, discover the need for significant figures.

3. Taking this measurement data, apply the concept of significant figures to recompute areas, volumes, and distances, time, and weights.

4. Given laboratory opportunity, isolate the concept of speed and relate it to the key concepts of straight line kinematics.

5. Given laboratory opportunity, discover acceleration, and its relation to the key concepts of kinematics.

6. Using corrected conclusions from speed and acceleration labs, differentiate between speed and acceleration in terms of mathematical problem solving.

7. Taking this experimental data, solve various problems to relate speed, acceleration, and distance to each other.

8. Taking this experimental data, demonstrate proficiency in the techniques of graphing.

9. Given a series of kinematics graphs, analyze relevant information.

10. Taking his experimental data, hypothesize why experimental results differ from theories of motion.

11. Given sufficient data, suggest a satisfactory coding system for straight line motion.

12. Given vector concepts, relate them to his coding system and data.

13. Solve problems interrelating speed, velocity, acceleration, distance, displacement, and average speed.

14. Given examples, identify physicists involved in the study of kinematics.

15. Given laboratory opportunity, discover a need for additional studies in the area of curvilinear motion (open ended).

COURSE OUTLINE

I. Time, Space, Matter

A. Demonstrations of motion
1. Hot wheels
2. Mass on string
3. Inclined plane
4. Student walking
5. Pendulum
6. Vibration (Train)
7. Falling body (Slot cars)
8. Projectile

B. Class discussion
1. Common factors
2. Exceptions

II. Measurement

A. Experiences in measurement
1. Groups measure room in cm., m., feet, yards, inches, and calculate area and volume.
2. Weigh various weights.
3. Differentiate and set up tables of three systems: (M.K.S., C.G.S., English).

B. Significant figures
1. Explore the need for and develop the use of significant figures.
2. Recompute laboratory findings using significant figures.
3. Develop the use of scientific notation.

III. Kinematics Laboratories

A. Various experiments performed by students as described under "Experiments".

B. Analysis of experiments
1. Interpretation
   a. speed
   b. distance
   c. acceleration
2. Problem solving
   a. speed
   b. distance
   c. acceleration

IV. Graphing

A. Making graphs from data
1. Speed vs. time
2. Distance vs. time
3. Acceleration vs. time

B. Analysis of Graphs
   1. Interpolation
   2. Extrapolation
   3. Areas under plotted data
   4. Slopes
   5. Introduction to Trigonometry
   6. Develop kinematic equations from graphs

V. **Analysis of data to explain why experimental data differs from theories of motion**

   A. Friction as opposition

   B. Measurement errors
      1. Time
      2. Distance

VI. Development of a Coding System to Distinguish Straight Line Kinematics from Other Types of Motion

VII. Vectors

   A. Introduction of vectors to replace student code
      1. Reasons for vectors
      2. Limitations (scalars, etc.)

   B. Application of Vectors
      1. Addition and subtraction
      2. Multiplication and division by scalars
      3. Resultant and equilibrant

   C. Methods of Vector Solutions
      1. Straight line
      2. Parallelogram
      3. Component
      4. Polygon (optional)

VIII. History of Study of Kinematics

   A. Need
      1. Need for further investigation
      2. Demonstration of types of curvilinear motion

EXPERIMENTS

Williams, Metcalfe, Trinklein, and Lefler. Exercises and Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

1. Measuring Length (Ex. 1, pp. 99-103)
2. Measuring Time (Ex. 3, pp. 107-109)
3. Acceleration (Ex. 12, pp. 127-131)

Physical Science Study Committee. Physics Laboratory Guide, 2nd. ed. Atlanta: D. C. Heath and Co., 1965.

4. Motion, Velocity and Acceleration (Ex. I-5, pp. 9-10)

Holton, Gerald, et al. The Project Physics Course, Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

5. Naked Eye Astronomy (Ex. 1, pp. 10-20)
6. Measuring Uniform Motion (Ex. 4, pp. 21-26)

Gillon and Smith. Concepts in Physics, Laboratory Manual. New York: Harcourt Brace and World, Inc., 1969.

7. Analyzing a motion with the Electric Timer (Ex. 5, pp. 7-8)

Lehrman and Swartz. Laboratory Experiments for Foundations of Physics. New York: Holt, Rinehart and Winston, Inc., 1965.

8. Speed and Acceleration (Ex. 8, pp. 18-21)

DEMONSTRATIONS

See ADDITIONAL INNOVATIVE ACTIVITIES

PROJECTS

1. Design and construct a tank in which water current could be measured. Build a small model boat powered with a battery. Measure the speed of the boat in still water relative to the tank, and then measure its speed relative to the tank with the water running.
2. Design and construct an apparatus that would enable you to measure the speed and acceleration of hot wheels rolling up, down, and horizontally along tracks.
3. Design and construct apparatus that would enable you to measure the speed of a plane flying overhead or at some distance from you.
4. Design and construct apparatus to demonstrate frictionless motion.
5. Design and construct a "perpetual motion" machine.
6. Design and construct an instrument that can be used at a fixed point, to measure the distance traveled and the speed of a moving mass.
7. Design and construct apparatus to prove the acceleration of a free-falling body.

REPORTS

1. The study of Kinematics by scientists.
   A. (500 B.C. - 500 A.D.)
   B. (500 A.D. - 1000 A.D.)
   C. (1000 A.D. - 1800 A.D.)
   D. (1800 A.D. - 1900 A.D.)
   E. (1900 A.D. - 1940 A.D.)
   F. (1940 A.D. - 1948 A.D.)
   G. (1948 A.D. - 1971 A.D.)
   H. (1971 A.D. - 2000 A.D.)
2. Sky rockets and space platforms.
3. How to - in auto racing.
4. What's up - in flying?
5. How to - in drag racing.
6. Fore - a golf ball in flight.
7. Strike - What's a curve ball?
8. Perpetual motion (a study)
9. The kinematics of a flowing river.

FIELD TRIPS

1. Driver education range.
2. Athletic field:
    A. Model plane flying.
    B. Team timing.
    C. Bicycle runs.
    D. Ball throwing.
    E. Walking, running.
    F. Baseball game.
3. Drag races
4. Airport
5. Plice cars
6. Boat races
7. Bowling alley
8. Driving range or golf course

SPEAKERS

1. Police Department Safety Speaker (Radar)
2. Traffic Engineer
3. Aerospace Speakers
4. Kinematics of Animals

RELATED PROBLEMS WITH ANSWERS

1. Dillon, Smith, Concepts in Physics, Teacher's Manual and Answer Key, 1970. (pp. 17-32)
2. P.S.S.C. Physics, Teacher's Guide, Part I, (Chap. 1-6)
3. Williams, Metcalf, Trinklein, Lefler, Modern Physics, Teacher's Edition, 1968., (pp. T24-T25)
4. Castka, Lefler, Physics Problems, 1961 (pp. 194-198)
5. Schaum, Daniel, Theory and Problems of College Physics, 6th Edition, (pp. 26-34)

DADE COUNTY 16mm FILMS

1. Motion and Time (Sterling)
   AV# 1-10672, 13' C
2. Straight Line Kinematics (0107) (MLA)
   AV# 1-30259, 33' BW
3. Vector Kinematics (0109) (MLA)
   AV# 1-10688, 16' BW
4. Vectors (0108) (MLA)
   AV# 1-30262, 28' BW
5. Velocity and Acceleration (Coronet)
   AV# 1-10688, 14' BW

FILM LOOPS

1. The Project Physics Course Materials, Holt, Rinehart and Winston, Inc., New York, 1970.

   Unit 1: Concepts of Motion $24.95 each

   PP 1. Acceleration Due to Gravity: Method 1
   PP 2. Acceleration Due to Gravity: Method 2
   PP 3. Vector Addition: Velocity of a Boat
   PP 4. A Matter of Relative Motion
   PP 5. Galilean Relativity: Part 1 - Ball Dropped from Mast of Ship
   PP 6. Galilean Relativity: Part 2 - Object Dropped from Aircraft
   PP 7. Galilean Relativity: Part 3 - Projectile Fired Vertically
   PP 8. Analysis of a Hurdle Race: Part 1
   PP 9. Analysis of a Hurdle Race: Part 2

2. Ealing, 1969 Science Teaching Catalog

   A. D. Kutliroff, New Brunswick Senior High School, Distance, Time and Speed, Cartridged Super-8, $21.50

   B. D. Kutliroff, New Brunswick Senior High School, One Dimensional Acceleration, $21.50

TRANSPARENCIES

A. The Project Physics Course Materials, Holt, Rinehart and Winston, Inc., New York, 1970. Super-8

Unit 1 - $65.50

1. T0 Using Stroboscopic Photographs
2. T1 Stroboscopic Measurement
3. T2 Graph of Various Motions
4. T3 Instantaneous Speed
5. T4 Instantaneous Rate of Change
6. T6 Derivation of $d = V_1 t + \frac{1}{2} at^2$
7. T8 The Tractor-Log Problem
8. T9 Projectile Motion
9. T10 Path of Projectile
10. T11 Centripetal Accel^ration

B. RCA 'Educator-Aides', R.C.A. Educational Services, R.C.A. Service Company, 1962, Camden 8, New Jersey.

11. M4 Positive and Negative Powers of Ten
12. M6 The Three Basic Systems of Measurements
13. M7 Significant Figures
14. M8 Scientific Notation
15. M9 Scalar and Vector Quantities
16. M11 Addition of Vectors
17. M12 Subtraction of Vectors
18. M22 Uniformly Accelerated Motion
19. M23 Uniform Acceleration
20. M24 Falling Objects in a Vacuum

SUGGESTED DISCUSSION QUESTIONS

1. What is kinematics?
2. What does frame of reference mean?
3. What is motion?
4. Can there be more than one frame of reference in motion? Why?
5. What is required for motion?
6. What types of motion are there?
7. How do we measure motion?
8. What contributes to errors in measurement?
9. How can we eliminate errors in measurement?
10. Where did the systems of measurement come from?
11. What are the units for measuring motion?
12. Isn't there a way to simplify all this math?
13. Will one speed value answer our problem?
14. Which values of speed, time and distance are helpful? (Suggestion: v_i, Av, v_f, At, d, Ad, a)
15. What can we show on graphs?
16. What can we interpolate from our motion graphs?
17. What can we extrapolate from our motion graphs?
18. Which method gives more reliable data? Why?
19. What's so bad about friction?
20. What's so good about friction?
21. In what ways is friction reduced? -- totally?
22. Is a picture worth a thousand words? (Vectors)
23. Can you draw a picture of 40 miles per hour south? Or 10 miles north?
24. Can you add pictures?
25. Why does the speedometer indicate only speed?
26. How can we indicate speed and direction?
27. How can we use vectors to help solve problems?
28. What scientists have contributed to our knowledge of Kinematics?
29. What kinds of motion don't we understand?

INNOVATIVE ACTIVITIES

1. Use of "hot wheels", slot cars, electric train, wind-up cars, bulldozer.

2. Photograph free-falling mass from school roof.

3. Have students demonstrate as many different types of motion as conceivable. (Ex: Yo-Yo, wheel, pump, buzzer, pendulum, orbit, free fall, wave action, torque, etc.)

4. Use a pulse in "slinky" for a distance-time relationship.

5. Roll a ball over a measured distance in corridor (or outside) at different speeds. Use data for class work.

6. Have student run upstairs. Relate to horizontal motion of same student.

7. Study trajectory of a paper wad fired from rubber band.

8. Analyze flights of paper airplanes.

9. Study hamster on exercise wheel.

10. Use pellet gun for moving mass experiments.

11. Measure height, length, and width of room using various measuring devices and systems. Compute surface areas and volume.

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1. Baker, D. Lee, et al. Elements of Physics. Boston: Allyn and Bacon, Inc., 1956.
2. Bennett, Clarence E. Physics Without Mathematics. New York: Barnes and Noble, 1949.
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25. Williams, John E., et al. Exercises and Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

MASTER SHEET - KINEMATICS

Objectives	Experiments	Student Text	Supplementary Reference Text	Film	Film Loops	Transparencies	Innovations
1		2 pp.28-30 3 pp.10-13 4 p.71	15 pp. 7-8 15 p. 54				3
2	1, 2	4 pp.19-25	15 pp. 7-14 pp. 22-35 18 p. 259 4 pp. 15-32			12, 1, 2	11
3	5	2 pp.12-16 4 pp. 25-31	15 pp. 15-18 15 pp. 34-36 18 pp. 248-249 4 pp. 61-66			11, 13, 14	
4	7, 6, 4	2 pp.30-34 3 pp.13-17 4 pp.71-73	15 pp. 54-60 18 pp. 26-27	BPI 1 BPI 2	PP 1 PP 2 PP 8 PP 9	4, 20	1, 2, 4, 5, 6, 7, 8, 10
5	3, 4	2 pp.34-41 3 pp.28-30 4 pp.77-83	15 pp. 71-75 18 pp. 26-27	BPI 2 BPI 5	PP 1 PP 2 PP 5 PP 6 PP 7	5, 18, 19	1, 2, 3, 5, 7
6 and 7	8	2 pp.49-52 3 pp.32-34 4 pp.76-77 4 pp.83-84	15 pp. 76-81 18 pp. 26-34 4 pp. 194-198 353,354			6	
8 and 9	6, 4	2 pp.16-19 3 pp.18-30 4 pp.33-34	15 pp. 54-75	BPI 2		3	
10							
11 and 12		2 pp.41-44 3 pp.70-75	15 pp. 82-102 18 p. 1 3 pp. 27A-117	BPI 3 BPI 4	PP 3	15, 16, 17	
13		2 pp.49-52 3 pp.32-34 4 pp.76-77 4 pp.83-84	15 pp. 76-81 103-104 18 pp. 26-34 4 pp. 194-198 353-354				
14							
15					PP 6 PP 8 PP 9	8, 9, 10, 7	3, 7, 9, 10